NODULES AND MOLECULES OF RED BLOOD-CORPUSCLES.

DESCRIPTIONS of human blood usually give the general form and dimensions and behavior of the red corpuscles, emphasizing the fact that mammalian blood in the mature condition is negatively characterized by the absence of nuclei. They fail, however, to note the presence of minute nodules, like excessively minute nuclei, one for each corpuscle as a general rule. These bodies, which are not always central in the corpuscle, appear under the microscope as dark rings, each with a bright, yellowish center. On first seeing them in coagulated human blood, I was puzzled by their being unexpected. Afterwards I found a row of them visible in profile along the edge of a layer of blood that had got bent up. In this case they were like minute mammæ, spherules protruding so as to show the yellow hue without a dark border. They soon came to be the best evidence of the presence of blood, being seen under the microscope at regular distances, as marking the component corpuscles of the clot; and they persist as the last recognizable parts of disintegrating blood.

Not being able to find any reference to them in our own language, I was directed by my colleague, Professor C. F. W. McClure, to an article on them by A. Negri in the *Anatomischer Anzeiger* of 1899, p. 33. That article referred to their discovery and description by Petrone of Catania in 1897; and reported an examination of human and dog's blood, comparing the nucleated condition of the red corpuscles of the fœtal blood with the non-nucleated condition in the adult. And after describing the form, aspect and position in the mature blood, of the bodies to which we may assign the name 'blood-nodules,' it described and figured a small body attached to the nucleus in the fœtal blood; adding that this is the body which after decay of the nucleus itself in mammals persists in the adult, and that it is not found in non-mammals.

After studying the account of Hæmoglobin, by Gamgee in the first volume of Schaefer's 'Text-book of Physiology,' I attempted to apply the results of the chemical work and the spectroscopic examination by recent authors to the problem of the molecular constitution of the blood corpuscle. According to Hüffner and others the hæmoglobin molecule is, chemically speaking, very large, numbering 16,669 as its molecular equivalent; and the explanation of this largeness is that it carries one atom of iron, which, being itself heavy, 56, requires a large vehicle, just as a gunboat is large because it is to carry a heavy cannon. The final cause of this arrangement appears to be that the molecule of hæmoglobin may insorb a molecule of oxygen gas, becoming specially associated with its atom of iron, in the form of FeO_2, receiving the charge of oxygen at the lungs, and afterwards discharging it into the tissues. This suggested the possibility of determining in an approximate way the absolute size of the molecule of hæmoglobin. I understand that this has not hitherto been done for any proteid; and the method here employed is general, and may be used wherever an organic substance combines in definite proportions with a gas.

Having measured the volume of the red blood-corpuscle, and taking 31 per cent. as its quantum of hæmoglobin, and 1.29 as the specific gravity (estimated from the whole corpuscle being about 1.09 sp. gr., of which 69 per cent. is water), I made out in milligrams the weight of the hæmoglobin for one corpuscle. Applying to this the well-established constant that one milligram of hæmoglobin insorbs 1.334 cubic millimeters of oxygen gas estimated at 0° C. and 760 mm. pressure, the product of these gave the volume of oxygen gas in-

sorbed by the single corpuscle as its full charge. Nernst's 'Theoretische Chemie' (1900, p. 394) gives the most reliable estimate of the number of molecules of oxygen, or any other gas, in a cubic millimeter at standard temperature and pressure. This is 55 thousand millions of millions (which may be written 55TMM). Calculated from this, the oxygen taken in by the single blood corpuscle as a full charge is found to be about 28 hundred millions of molecules. But as the combination is known to be regularly one molecule of the gas to one molecule of hæmoglobin, this result, or in round numbers three thousand millions, is approximately the number of hæmoglobin molecules in the blood-corpuscle (3 TM).

Dividing this last number into the volume of the hæmoglobin in a corpuscle, we obtain the volume of the cubic 'room' assigned by chemists to each molecule, and the cube root of this will give the length of the imaginary walls of said room, also nearly the diameter of the molecule regarded as a sphere in a solid state. The volume is approximately $1/10^{17}$ cubic millimeters, and the linear dimension of the side of a molecule 'room' is about 1/500,000 of a millimeter. The 'rooms' of the oxygen molecules in the gaseous condition are much larger than these, because the gases rejoice in spacious apartments; in fact, the volume of gas which is insorbed by the blood is nearly twice as great as that of the devouring hæmoglobin.

Nernst states that by multiplying the absolute atomic weight of hydrogen upon the molecular formula of any proteid, we may obtain the absolute weight of the proteid. This involves, we think, the assumption that no condensation has occurred in building up proteid molecules. In order to test the rule by hæmoglobin, we find that this rule gives as the absolute molecular weight $1.35 \times (10)^{-17}$ of a milligram. By the method of the quantitative absorption given above of oxygen the value comes out as $1.30 \times (10)^{-17}$ of a milligram. The two results differ by less than 4 per cent. This close harmony does not prove that the estimated weight of the atom of hydrogen is right, for it enters into both methods; but it does prove non-condensation, and also confirms the quantitative results of Hüffner and others as to the absorption of oxygen. It may be added that the oxygen absorbed is, when estimated in its fluid form, about 1/470 the volume of the absorbing hæmoglobin.

But probably if the oxygen were examined in the liquefied or solidified condition, its molecular sphere of action would be found not to be so very widely divergent from its rightful proportion of 32 to 16,669.

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SCIENTIFIC BOOKS.

Leçons sur les séries divergentes. Par ÉMILE BOREL, maître de conférences a l' Ecole Normale Supérieure. Paris, Gauthier-Villars. 1901. Pp. vi + 182.

La Série de Taylor et son prolongement analytique. Par JACQUES HADAMARD. Scientia, série physico-mathématique. Chartes, imprimerie Durand. 1901. Pp. viii + 102.

These two works can appropriately be classed together, on account of both their authorship and their contents. Among the younger French mathematicians who have taken their doctors' degrees within the past dozen years none are to-day more conspicuous than Hadamard and Borel. Their theses were published in 1892 and 1894 respectively. A few years later both writers were recipients of prizes from the French Academy of Sciences. In 1896 Hadamard received the 'Prix Bordin' for his work on geodesics, while Borel won the 'Grand Prix des sciences mathématiques' in 1898 for his investigations upon divergent series. Recently also they have been bracketed in a list of nominees to fill a vacancy in the Academy of Sciences.

We have here to consider two representative